



MEMORANDUM

To: EPA
Copy To: File 80021
From: J. Lambert, J. Brunelle
Subject: Olin Chemical Superfund Site – DAPL Extraction Alternatives v2.2
Date: 7/19/19

This technical memorandum (Memo) describes potential alternatives to address dense aqueous phase liquid (DAPL) pools at the Olin Chemical Superfund Site (the Site). Wood Environment & Infrastructure, Inc [Wood] proposed alternatives including DAPL extraction in the Interim Action Feasibility Study (IAFS) (Wood, 2019); however, the U.S. Environmental Protection Agency (EPA) requested that Nobis Group® (Nobis) propose additional, more intensive alternatives to address DAPL. The following sections provide background and technical justification for expanded DAPL alternatives and include costs for Olin’s alternatives presented in their IAFS, for alternatives proposed by Nobis, and for alternatives proposed in the IAFS using revised volume estimates. All costs are based on IAFS unit costs as provided in the IAFS Table 4.3-2 through Table 4.3-4. The following sections are organized by area.

1.0 CONTAINMENT AREA

The IAFS (Wood, 2019) proposes DAPL extraction using a single extraction point in the Containment Area (Figure 1A). The following subsections describe the IAFS alternative in more detail, discuss the data gaps and uncertainties associated with the Containment Area, and propose a revised alternative for the Containment Area.

1.1 IAFS Alternative

The IAFS provides one alternative for DAPL extraction in the Containment Area (Figure 1A). Olin proposes to install a single extraction well in the center of the presumed DAPL pool. This extraction well would be installed to the top of the bedrock surface, with a two-foot screen. Olin would install one induction logging well and one multi-level well close to the new extraction well.



All new wells would be constructed in the same manner as the extraction, induction logging, and multi-level monitoring wells installed at Jewel Drive (Off-Property West Ditch (OPWD)) DAPL pool during the DAPL removal pilot test. Olin would extract DAPL at a rate of 0.25 gallons per minute (gpm), with an estimated 2-year extraction duration (assuming the Containment Area holds 190,000 gallons of DAPL).

1.2 Data Gaps/Uncertainties

Primary areas of uncertainty at the Containment Area with respect to designing a robust DAPL extraction alternative are described below. Additional data may be needed to fully evaluate other alternatives or other media, (such as groundwater).

Bedrock Topography:

The bedrock topography is a critical data gap at the Containment Area because the success of the DAPL extraction depends on the extraction well's location at the bottom of the DAPL pool; however, Olin has not adequately defined Containment Area bedrock. Data gaps are as follows:

- Few borings were advanced within the DAPL pool to confirm bedrock – Olin installed bedrock confirmation borings around the slurry wall to support slurry wall design, but relatively few points were located within the DAPL pool.
- The configuration of the bedrock saddle at the eastern edge of the DAPL pool is not well defined.

Figure 1A shows the superimposed bedrock contours developed separately by Nobis and Wood. Both interpretations suggest considerable variation in potential bedrock topography. East-west and north-south cross-sections of the Containment Area DAPL pool are shown in Figure 1B and 1C, respectively.

Surface geophysics and bedrock confirmation borings (bedrock cores to confirm and characterize shallow bedrock) are needed as part of a pre-design investigation (PDI) to determine final locations for DAPL extraction and monitoring wells.

DAPL Characteristics:

Nobis (2019) developed a range of DAPL volumes using bedrock and top of DAPL (TOD) elevations generated by both Nobis and Wood. Nobis' estimated DAPL volume ranges from



450,000 to 660,000 gallons and is higher than Olin's estimate provided in the IAFS (200,000 gallons). Nobis is using an estimate of approximately 610,000 gallons (based on the maximum reasonable TOD and bedrock contours) to develop costs and time to complete remediation.

As shown in Figure 1A, only one multi-port monitoring well (MP-1) is located within the 5-acre Containment Area. Five additional monitoring wells with 5 to 10-foot screens are located within the containment area, but the screen length does not allow for accurate evaluation of the DAPL elevation or chemistry.

At least two additional multi-port wells are needed northeast and west of MP-1 to provide chemical profiles with depth and to determine a more accurate DAPL volume. These locations may be revised based on the bedrock topography evaluation that should provide an updated understanding of the bottom of the DAPL pool.

Bedrock Characteristics:

Olin has installed three bedrock boreholes in the Containment Area. In 2018, Wood installed two bedrock boreholes at the northwest and southern edge of the Containment Area. Prior to 2018 Olin installed BR-1 at the southwestern corner of the Containment Area. Olin has not performed bedrock lithology/fracture characterization beneath the DAPL pool, between DAPL pools, or downgradient of the DAPL pool to confirm that the DAPL does not extend into bedrock.

Additional bedrock investigation is needed to evaluate DAPL extraction within bedrock as part of a PDI for this alternative (it is assumed that Olin will evaluate OU3 groundwater on a separate track). These should include bedrock borings (including separate shallow and deep bedrock boreholes) in the following locations within the Containment Area:

- West of the DAPL pool (north of the presumed bedrock saddle) to determine the potential for DAPL transport in bedrock and confirm bedrock characteristics,
- East of the DAPL pool (downgradient) to evaluate if fractures contain extractable DAPL:
- Beneath the DAPL pool (may require specialized techniques to minimize cross-contamination) to evaluate the competency of the bedrock basin.
- Two other locations to be determined based on earlier phases of work that will provide a better understanding of the bedrock topography and local bedrock fracture network.

Olin should evaluate bedrock boreholes using borehole geophysics and discrete-interval sampling.



1.3 Proposed Alternative

Nobis recommends installing multiple extraction wells to maximize DAPL extraction rates and allow for even drawdown across the DAPL pool. These include a central DAPL extraction well at the deepest part of the DAPL pool (assumed to be the same central location recommended by Wood) and three auxiliary DAPL extraction wells located between the primary DAPL extraction well and the edge of the DAPL pool.

These locations would be adjusted based on revised bedrock topography determined in the PDI described in Section 1.2. Use of auxiliary extraction points would allow for relatively slow DAPL extraction at each point (assumed to be 0.25 gpm for planning purposes) and reduce the drawdown at any given point. The total extraction rate is assumed to be 1 gpm. Each extraction well would be paired with two multi-port monitoring wells at different distances to monitor extraction progress and the shape of the drawdown curve.

EPA has suggested that at least one significant bedrock fracture or fracture zone containing DAPL is present within the Containment Area. Extractable DAPL within identified fractures will be addressed with an extraction well; however, Nobis assumes that this well will produce a relatively low volume of DAPL. No adjustment has been made to the estimated volume of the DAPL pool to account for the relatively low volume of DAPL in bedrock fractures.

1.4 Alternative Comparison

Table 1 presents a comparison of the DAPL Alternatives. Refer to Attachment A for cost details. Each Containment Area (CA) DAPL Alternative is described below:

CA Alternative 1 – Olin’s Volume and Extraction Rate

Olin’s proposed extraction of 200,000 gallons of DAPL at 0.25 gpm would take approximately 1.9 years to complete at a cost of \$1.0 million, as described in the IAFS (Wood, 2019).

CA Alternative 2 – Olin’s Extraction Rate and Nobis’ Volume

The extraction of Nobis’ proposed volume of DAPL (610,000 gallons) using Olin’s proposed infrastructure (1 extraction well at 0.25 gpm) would take approximately 5.8 years to complete at a cost of \$1.9 million, which is similar to the cost estimated using Nobis’ volume and extraction rate below.



CA Alternative 3 – Nobis’ Volume and Extraction Rate

Nobis’ proposed extraction of 610,000 gallons of DAPL at 1.0 gpm (combined from 4 wells) would take approximately 1.5 years to complete at a cost of \$2.1 million.

Nobis’ TOD calculations and bedrock topography interpretations differ from Olin’s. Based on these factors, Nobis calculated a higher volume of DAPL. Nobis’ alternative also presents an increased total pumping rate (via additional extraction wells) compared to Olin’s rate presented in their IAFS. Nobis’ alternative costs are higher due to increased volume of DAPL and the increased installation and operational costs included with the additional pumping infrastructure.

2.0 JEWEL DRIVE

The IAFS (Wood, 2019) proposes DAPL extraction using a single extraction point in the Jewel Drive or Off-Property West Ditch (OPWD) DAPL pool (Figure 1A) and includes the possibility of installing a second well east of the building. The following subsections describe the IAFS alternative in more detail, discuss the data gaps and uncertainties associated with the OPWD DAPL pool area, and propose a revised alternative.

2.1 IAFS Alternative

The IAFS (Wood, 2019) proposes replacing the existing DAPL extraction well with a new well adjacent to the current vault. New well construction would use a 2-foot screen instead of the current 5-foot screen (Figure 2A). The current extraction well may be converted to multilevel well or replaced with a new multi-level well.

The alternative also includes additional borings at the southeastern and northeastern corners of the building to confirm existing seismic data, and installation of a second extraction well at the east side of the building. The extraction wells would be pumped at 0.25 gpm each (0.5 gpm total). The IAFS does not depict the locations of the potential additional extraction or monitoring wells.



2.2 Data Gaps/Uncertainties

Primary areas of uncertainty at the OPWD DAPL pool include the following:

Bedrock Topography:

The area around the building has been characterized using surface geophysics, direct-push technology (DPT) borings to tag bedrock, and multi-port and conventional monitoring wells, as shown in Figure 2A. However:

- The area immediately south of the building and within the building footprint has not been characterized.
- Bedrock has not been confirmed via coring except at GW-42D, south of the building.

Additional investigation is needed as part of a PDI to determine final locations for DAPL extraction and monitoring wells. Olin should include cored bedrock borings north and south of the building as well as within the building footprint in addition to the two confirmation borings at the southeast and northeast corners of the building proposed by Wood.

Angled borings may be used if coring cannot be performed inside the building. Olin should perform additional surface geophysics to resolve the bedrock topography inside and south of the building. DPT transects or a series of angled borings may be used if surface geophysics cannot be performed.

DAPL Characteristics

Nobis (2019) developed a range of DAPL volumes using bedrock and TOD elevations generated by both Nobis and Wood. Nobis' estimated DAPL volume ranges from 0.9 to 1.4 million gallons. Although Olin's estimate provided in the IAFS is within Nobis' range (1 million gallons), Nobis recommends an estimate of approximately 1.4 million gallons (based on the maximum reasonable TOD and bedrock contour interpretations) to develop costs and time to complete remediation.

As shown in Figure 2A, the multi-port wells at the OPWD DAPL pool are located at the western and southern edges of the DAPL pool. At least two multi-port wells are needed beneath the building and northeast of the building to provide chemical profiles with depth and to determine a more accurate DAPL volume. One of these multi-port wells should target the area of deepest bedrock based on the bedrock topography elevation described above.



Bedrock Characteristics:

Bedrock characteristics have not been evaluated close to the OPWD DAPL pool. While additional bedrock investigation is anticipated to evaluate OU3 groundwater (on a separate track), some evaluation will be required as part of a PDI to assess the need for DAPL extraction within bedrock. These should include bedrock borings (including separate shallow and deep bedrock boreholes) in the following locations:

- Northwest of the DAPL pool (between the OPWD and Main Street DAPL pools) to determine the potential for DAPL transport in bedrock and confirm bedrock characteristics,
- Beneath the DAPL pool (may require specialized techniques to minimize cross-contamination) to evaluate the competency of bedrock and identify fracture zones.
- Two other locations to be determined based on earlier phases of work to develop a better understanding of the bedrock topography and local bedrock fracture network.

Bedrock boreholes would be evaluated with borehole geophysics and discrete-interval sampling as needed.

2.3 Proposed Alternative

Olin should install multiple extraction wells to maximize DAPL extraction rates and allow for even drawdown across the DAPL pool. In addition to Wood's proposed EW-2 replacement, Olin should install a DAPL extraction point at the lowest point in the basin (assumed to be beneath the center of the building). One or more angled extraction wells should be installed from outside the building to target the deepest concentrations if an extraction well cannot be installed directly beneath the building.

In addition, Olin should install auxiliary DAPL extraction wells between the edge of the DAPL pool and the central extraction point to minimize drawdown and provide flexibility with pumping rates. Suggested locations are shown in Figure 2A. Use of auxiliary extraction points would allow for relatively slow DAPL extraction at each point (0.25 gpm for planning purposes) and reduce the drawdown at any given point. The total extraction rate from all the proposed extraction points is assumed to be 1 gpm. Depending on the variability of the bedrock surface, it may be necessary to add a second extraction well to target the area beneath the building.



Each extraction well should be paired with two multi-port monitoring wells at different distances from the extraction well to monitor extraction progress and the shape of the drawdown curve.

2.4 Alternative Comparison

Table 1 presents a comparison of the DAPL Alternatives. Refer to Attachment A for cost details. Each OPWD DAPL Alternative is described below:

OPWD Alternative 1 – Olin’s Volume and Extraction Rate

Olin’s proposed extraction of 1,000,000 gallons of DAPL at 0.25 gpm would take approximately 9.5 years to complete at a cost of \$2.5 million, as described in the IAFS (Wood, 2019).

Although Olin’s Table 4.3-2 in the IAFS presents costing for both the replacement of the existing extraction well (installed during the DAPL Pilot Study) and the installation of a second, new extraction well, proposed extraction rates (0.25 gpm) and operational timing (9.5 years) suggest the operation of only one well. Nobis assumes that Olin will operate one extraction well for this alternative for comparative purposes.

OPWD Alternative 2 – Olin’s Extraction Rate and Nobis’ Volume

The extraction of Nobis’ proposed volume of DAPL (1,400,000 gallons) using Olin’s proposed infrastructure (1 replacement extraction well at 0.25 gpm) would take approximately 13.3 years to complete at a cost of \$2.6 million.

OPWD Alternative 3 – Nobis’ Volume and Extraction Rate

Nobis’ proposed extraction of 1,400,000 gallons of DAPL at a total of 1.0 gpm via 4 wells would take approximately 3.3 years to complete at a cost of \$3.8 million.

Nobis’ TOD calculations and bedrock topography interpretations differ from Olin’s. Based on these factors, Nobis calculated a higher volume of DAPL. Nobis’ alternative also presents an increased total pumping rate (via additional extraction wells) relative to Olin’s rate presented in their IAFS. Nobis’ alternative costs are higher due to increased volume of DAPL and the increased installation and operational costs included with the additional pumping infrastructure.

Although Nobis’ alternative is more expensive than Olin’s, it is likely more effective since our approach targets the area where the DAPL is expected to be deepest (under the building) and removes the source of contamination much faster.

3.0 MAIN STREET

The IAFS (Wood, 2019) proposes DAPL extraction using a three extraction points in the Main Street DAPL pool (Figure 3A). The following subsections describe the IAFS alternative in more detail, discuss the data gaps and uncertainties associated with the Main Street DAPL pool area, and propose a revised alternative.

3.1 IAFS Alternative

The IAFS (Wood, 2019) proposes installing three extraction wells near DP-5, DP-9, and DP-11. Each well would be constructed similarly to the current EW-1 but would use a 2-foot screen set at the top of bedrock (instead of a 5-foot screen).

Olin proposes to install one induction logging well and one multilevel piezometer near each extraction well, and three additional multilevel piezometer/induction logging well pairs (6 total) would be distributed throughout the DAPL pool; however, Olin's alternative only includes costing for the multilevel piezometers and induction logging wells associated with the extraction wells; no cost is carried for the additional points to be installed throughout the DAPL pool.

Olin proposes to pump the extraction wells at 2 gpm each (6 gpm total) as Olin assumes that the steeper sides of the Main Street DAPL pool basin would allow for higher pumping rates than the other pools. Wood notes that that it may become necessary to progressively reduce the rate of DAPL extraction.

3.2 Data Gaps/Uncertainties

Primary areas of uncertainty at the Main Street DAPL pool include the following:

Bedrock Topography:

The eastern end of Eames Street and the area to the west (northern third of the Main Street DAPL pool) have been evaluated with surface geophysics and a DPT investigation. However:

- Except for GW-44D, confirmation bedrock boreholes have not been installed.
- The available data in this area suggest large variations in bedrock surface topography.
- The southern 2/3 of the DAPL pool has relatively few data points for comparison.



- It is not clear if the bedrock surface is more variable in the north or if the variance is caused by a larger number of points that are relatively close together.

Additional investigation is needed as part of a PDI to determine final locations for DAPL extraction and monitoring wells. Olin should perform additional surface geophysics along Main Street and the available parking lots and other paved areas throughout the Main Street DAPL pool area, followed by bedrock confirmation using bedrock coring. DPT may be used in areas where surface geophysics are not feasible but should not be considered a substitute for bedrock confirmation.

DAPL Characteristics

Nobis (2019) developed a range of DAPL volumes using bedrock and TOD elevations generated by Nobis, EPA, and Wood. Nobis' estimated DAPL volume ranges from 13 to 21 million gallons. Wood's estimate provided in the IAFS is 13 million gallons. Nobis recommends an estimate of approximately 17.5 million gallons (based on the maximum reasonable TOD and bedrock contour interpretations) to develop costs and time to complete remediation.

As shown in Figure 3A, the only multi-port well located within the Main Street DAPL pool (MP-3) is in the far northeast corner. It is unclear how much the DAPL pool elevation can be extrapolated from this point, given the size of the pool and the fact that MP-3 appears to be somewhat isolated from the rest of the pool. At least four additional multi-port monitoring wells should be installed to ensure coverage of the area: at the apparent low spot close to DP-11 in the southern portion of the DAPL pool; at the center of the DAPL pool (apparent low spot close to DP-5), at the downgradient bedrock depression that may be a conduit for DAPL migration (south of DP-14), and at the northeastern lobe of the DAPL pool south and southeast of DP-4.

Bedrock Characteristics:

Bedrock has not been evaluated other than shallow bedrock confirmation in the Main Street DAPL pool area. This area is critical for evaluating potential bedrock transport to the Maple Meadow Brook Wetland (MMBW) area.

While additional bedrock investigation is anticipated for the OU3 RI/FS, some evaluation will be required as part of a PDI to assess the need for DAPL extraction within bedrock. These should include bedrock borings (including separate shallow and deep bedrock boreholes) in the following locations:



- Northwest end of the DAPL pool at the bedrock saddle to evaluate bedrock trends and potential need for bedrock DAPL extraction in this area;
- North-central portion of the DAPL pool (south of DP-9) to evaluate potential for significant fractures in line with the bedrock saddle;
- Central DAPL pool (west of GW-45D/S): evaluate potential for a significant fracture network that may connect the observed bedrock lows;
- South end of the DAPL pool (east of former GW-59D/S) to evaluate potential fracture zones associated with apparent bedrock low;
- Three other locations to be determined based on earlier phases of work that will develop a better understanding of the bedrock topography and local bedrock fracture network.

Bedrock boreholes would be evaluated with borehole geophysics and discrete-interval sampling as needed. Specialized drilling methods may be required to prevent cross-contamination during drilling.

3.3 Proposed Alternative

The Main Street DAPL pool is significantly larger than the other pools, and other extraction points will be required in addition to the three extraction wells proposed by Wood. As described in Section 1.3 and Section 2.3, multiple extraction wells are required to allow for higher pumping rates overall while minimizing drawdown at any given location.

The extraction well locations and configuration may change after the more detailed bedrock topography investigations described above are completed. However, based on existing information, it is reasonable to assume that the bedrock lows associated with DPT data represent a trend of relatively low elevations. Therefore, two extraction wells should be installed between the two southern extraction wells proposed by Wood, with one extraction well installed west of the southernmost extraction well proposed by Wood (east of GW-59D/S) and an additional six extraction wells installed for full coverage in the northern portion of the DAPL pool.

Given Olin's experience with DAPL removal at the OPWD DAPL pool, a 2 gpm flow rate per well is optimistic. Instead of 2 gpm per well (6 gpm total), Nobis recommends using an assumption of 0.5 gpm per well (twice the sustainable rate at the OPWD DAPL pool). This would result in an overall removal rate of 6 gpm for the 12 extraction wells. Each extraction well should be paired with two multi-port monitoring wells at different distances from the extraction well to monitor extraction progress and the shape of the drawdown curve.



3.4 Alternative Comparison

Table 1 presents a comparison of the DAPL Alternatives for Main Street (MS). Refer to Attachment A for cost details. Each OPWD DAPL Alternative is described below:

MS Alternative 1 – Olin’s Volume and Extraction Rate

Olin’s proposed extraction of 13,000,000 gallons of DAPL at a total 6.0 of gpm via 3 wells would take approximately 5.2 years to complete at a cost of \$26.1 million.

MS Alternative 2 – Olin’s Maximum Extraction Rate and Nobis’ Volume

The extraction of Nobis’ proposed volume of DAPL (17,500,000 gallons) using Olin’s proposed infrastructure (3 extraction wells at 6.0 gpm would take approximately 6.9 years to complete at a cost of \$33.8 million.

MS Alternative 3 – Nobis’ Volume and Extraction Rate

Nobis’ proposed extraction of 17,500,000 gallons of DAPL at a total of 6 gpm via 12 wells would take approximately 6.9 years to complete at a cost of \$35.6 million.

Nobis’ TOD calculations and bedrock topography interpretations differ from Olin’s. Based on these factors, Nobis calculated a higher volume of DAPL. Nobis has proposed additional extraction wells to provide a much more conservative pumping rate per well (Nobis used double the sustainable rate in the OPWD DAPL pool instead of 8 times the pumping rate proposed by Olin).

Because of Nobis’ increase in proposed infrastructure, the capital costs included in this alternative are almost double those proposed by Olin in MS Alternative 1. Nobis’ overall alternative costs are also higher due to increased volume of DAPL and these additional capital costs. Although Nobis’ alternative is more expensive than Olin’s, our approach results in a more effective pumping configuration that is able to target more bedrock low areas and draw down the DAPL pool more evenly. Note that even with the increase in infrastructure, the cost for this alternative is close to the calculated cost for MS Alternative 2.



4.0 ASSUMPTIONS

Assumptions used for developing alternate cost estimates are described below.

Unit costs: Nobis did not add other alternative components, but instead adjusted quantities to develop DAPL alternatives. In addition, Nobis did not independently develop or verify the unit costs in the IAFS. Nobis used the same unit costs as the IAFS, except for electricity and monitoring costs. Nobis assumed that the annual electricity and monitoring costs were double for the Nobis alternatives because those alternatives had substantial increased infrastructure (generally 4 times the number of extraction wells).

DAPL pumping rate: Nobis calculated the pumping rate for its alternatives based on the total pumping rate (in gpm) for each alternative, multiplied by an operating time of 80% to determine an annual pumping rate for DAPL disposal costs. The DAPL pumping rates in the IAFS were slightly different from this calculated pumping rate, and those rates specific to the IAFS were used for the non-Nobis alternative costs to maintain consistency with the IAFS.

Discount factor: Nobis used the discount factors provided in the IAFS cost tables to calculate the present values. The IAFS discount factors are shown to four significant figures. The present value calculated by Nobis may be slightly different from that provided in the IAFS due to accumulated rounding errors.

5.0 REFERENCES

Nobis, 2019. Olin Chemical Superfund Site: Evaluation of DAPL and NDMA to support Feasibility Study review and development of DAPL and groundwater alternatives. July 19.

Wood, 2019. Draft Interim Action Feasibility Study, Olin Chemical Superfund Site, Wilmington, Massachusetts. April.

Table 1
DAPL Alternative Comparison
Olin Chemical Superfund Site
Wilmington, Massachusetts
Page 1 of 1

Alternative		DAPL Volume (gal)	No. Extraction Wells	Total Extraction rate (gpm)	Operating Time	Estimate to Complete (years)	Cost (Present Value, \$M)
Containment Area DAPL Pool							
CA Alternative 1	Olin - IAFS Assumptions	200,000	1	0.25	80%	1.9	1.012
CA Alternative 2	Olin Extraction Rate, Nobis Volume	610,000	1	0.25	80%	5.8	1.933
CA Alternative 3	Nobis Assumptions	610,000	4	1.0	80%	1.5	2.100
Jewel Drive (OPWD) DAPL Pool							
OPWD Alternative 1	Olin - IAFS Assumptions ¹	1,000,000	1	0.25	80%	9.5	2.487
OPWD Alternative 2	Olin Extraction Rate, Nobis Volume	1,400,000	1	0.25	80%	13.3	2.585
OPWD Alternative 3	Nobis Assumptions	1,400,000	4	1.0	80%	3.3	3.765
Main Street DAPL Pool							
MS Alternative 1	Olin - IAFS Assumptions	13,000,000	3	6.0	80%	5.2	26.091
MS Alternative 2	Olin Max Extraction Rate, Nobis volume	17,500,000	3	6.0	80%	6.9	33.799
MS Alternative 3	Nobis Assumptions	17,500,000	12	6.0	80%	6.9	35.598

Notes:

1. Although Olin's Table 4.3-2 in the IAFS presents costing for the replacement of the existing extraction well and the installation of a second, new extraction well, proposed extraction rates (0.25 gpm) and timing (9.5 years) suggest the operation of only one well.
2. See Attachment A for cost details.

R:\80000 Task Orders\80021 Olin Chemical\Technical Data (TD)\GIS_Data\Maps_Figures\DAPL Cross Sections\Olin DAPL X-Sections 2019.mxd 7/17/2019 14:02 jharrington



Notes:

1. Bedrock contours from Olin, 2018. Results of Containment Area Bedrock Borings, Olin Chemical Superfund Site, (OCSS), Wilmington, MA. May 10.
2. This Site Sketch was developed from elevation data from Mactec, Amec Foster Wheeler, Wood, and observations made by Nobis.
3. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

- ▲ Conventional Screened Wells
- Bedrock Confirmation Location
- Multi-Port Well
- ⊕ IAFS Proposed Extraction Well
- ⊕ Additional DAPL extraction points proposed by Nobis
- Most recent bedrock contours supplied by Olin
- Nobis Bedrock Contour
- Cross Section Transect
- Geophysical Line
- Maximum estimated DAPL extent
- Containment Area
- Paved Road
- Rail
- - - Site Boundary
- Water Features
- Buildings
- Wetlands
- Cross Section Transect

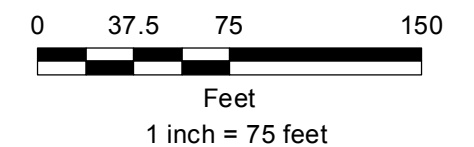


FIGURE 1A

CROSS SECTION TRANSECTS
CONTAINMENT AREA
OLIN CHEMICAL SUPERFUND SITE
WILMINGTON, MASSASHUSETTS

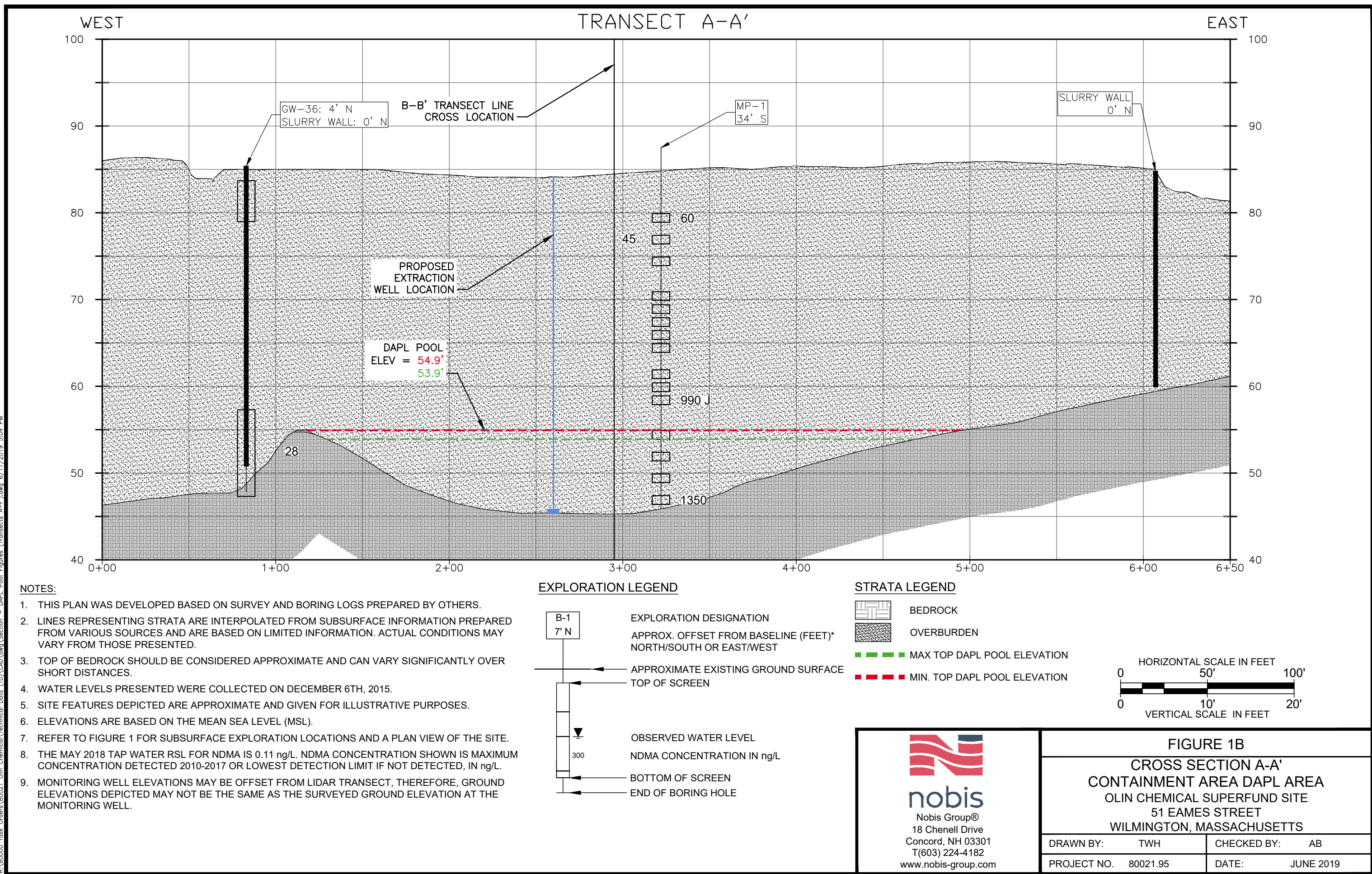
PREPARED BY: JH
PROJECT NO. 80021

CHECKED BY: JL
DATE: JUNE 2018

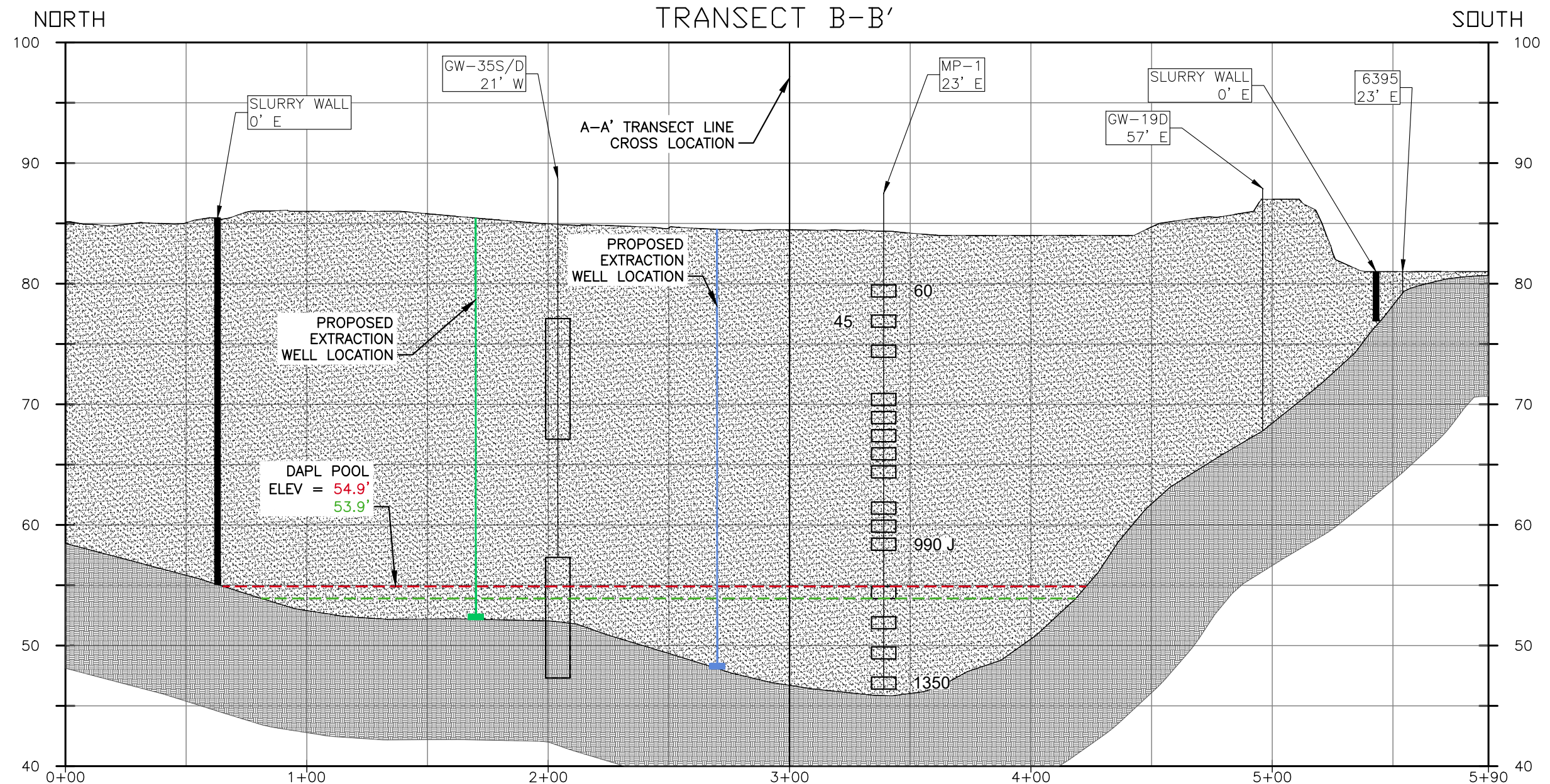


Nobis Group® - 585 Middlesex Street
Lowell, MA 01851 - (978) 683-0891
www.nobis-group.com

R:\80000 Task Orders\80021 Olin Chemical\Technical Data (TD)\CAD\dwg\Section - DAPL Pool Figures (Transects A-F).dwg 6/17/2019 5:04 PM



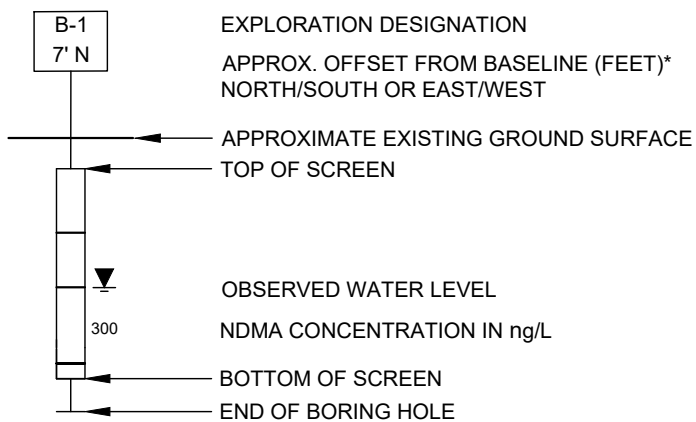
R:\80000 Task Orders\80021 Olin Chemical\Technical Data (TD)\CAD\dwg\Section - DAPL Pool Figures (Transects A-F).dwg 6/17/2019 5:04 PM



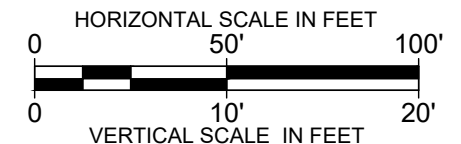
NOTES:

1. THIS PLAN WAS DEVELOPED BASED ON SURVEY AND BORING LOGS PREPARED BY OTHERS.
2. LINES REPRESENTING STRATA ARE INTERPOLATED FROM SUBSURFACE INFORMATION PREPARED FROM VARIOUS SOURCES AND ARE BASED ON LIMITED INFORMATION. ACTUAL CONDITIONS MAY VARY FROM THOSE PRESENTED.
3. TOP OF BEDROCK SHOULD BE CONSIDERED APPROXIMATE AND CAN VARY SIGNIFICANTLY OVER SHORT DISTANCES.
4. WATER LEVELS PRESENTED WERE COLLECTED ON DECEMBER 6TH, 2015.
5. SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
6. ELEVATIONS ARE BASED ON THE MEAN SEA LEVEL (MSL).
7. REFER TO FIGURE 1 FOR SUBSURFACE EXPLORATION LOCATIONS AND A PLAN VIEW OF THE SITE.
8. THE MAY 2018 TAP WATER RSL FOR NDMA IS 0.11 ng/L. NDMA CONCENTRATION SHOWN IS MAXIMUM CONCENTRATION DETECTED 2010-2017 OR LOWEST DETECTION LIMIT IF NOT DETECTED, IN ng/L.
9. MONITORING WELL ELEVATIONS MAY BE OFFSET FROM LIDAR TRANSECT, THEREFORE, GROUND ELEVATIONS DEPICTED MAY NOT BE THE SAME AS THE SURVEYED GROUND ELEVATION AT THE MONITORING WELL.

EXPLORATION LEGEND



STRATA LEGEND



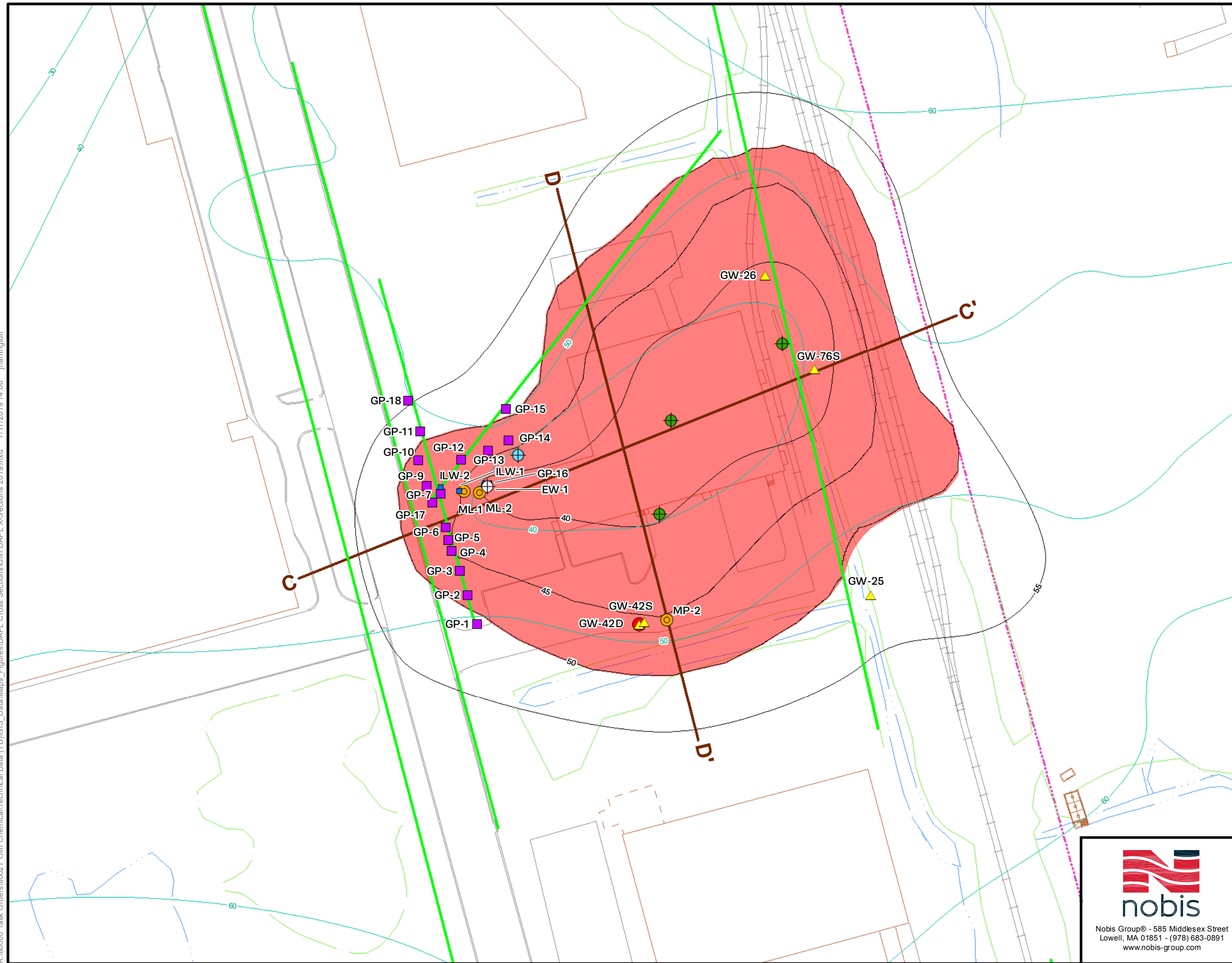
nobis
Nobis Group®
18 Chenell Drive
Concord, NH 03301
T(603) 224-4182
www.nobis-group.com

FIGURE 1C

CROSS SECTION B-B'
CONTAINMENT AREA DAPL AREA
OLIN CHEMICAL SUPERFUND SITE
51 EAMES STREET
WILMINGTON, MASSACHUSETTS

DRAWN BY:	TWH	CHECKED BY:	AB
PROJECT NO.	80021.95	DATE:	JUNE 2019

R:\80000 Task Orders\80021 Olin Chemical\Technical Data (TD)\GIS_Data\Maps_Figures\DAPL Cross Sections\Olin DAPL X-Sections 2019.mxd 7/17/2019 14:06 jharrington



Notes:

1. Bedrock contours from AMEC, 2015. DAPL Extraction Pilot Study Performance Evaluation Report Supplemental Water Level and Hydraulic Analysis. February 5.
2. This Site Sketch was developed from elevation data from Mactec, Amec Foster Wheeler, Wood, and observations made by Nobis.
3. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

- ▲ Conventional Screened Well
- Bedrock Confirmation Location
- Multi-Port Well
- Induction Logging Well
- ⊕ Existing Extraction Well
- ⊕ IAFS Proposed Extraction Well
- Additional DAPL extraction points proposed by Nobis
- DPT Locations
- Most recent bedrock contours supplied by Olin
- Nobis Bedrock Contour
- Cross Section Transect
- Geophysical Line
- Maximum estimated DAPL extent
- Paved Road
- Rail
- Site Boundary
- Water Features
- Buildings
- Wetlands

0 37.5 75 150
Feet
1 inch = 75 feet

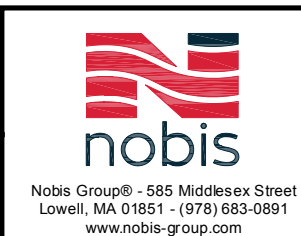
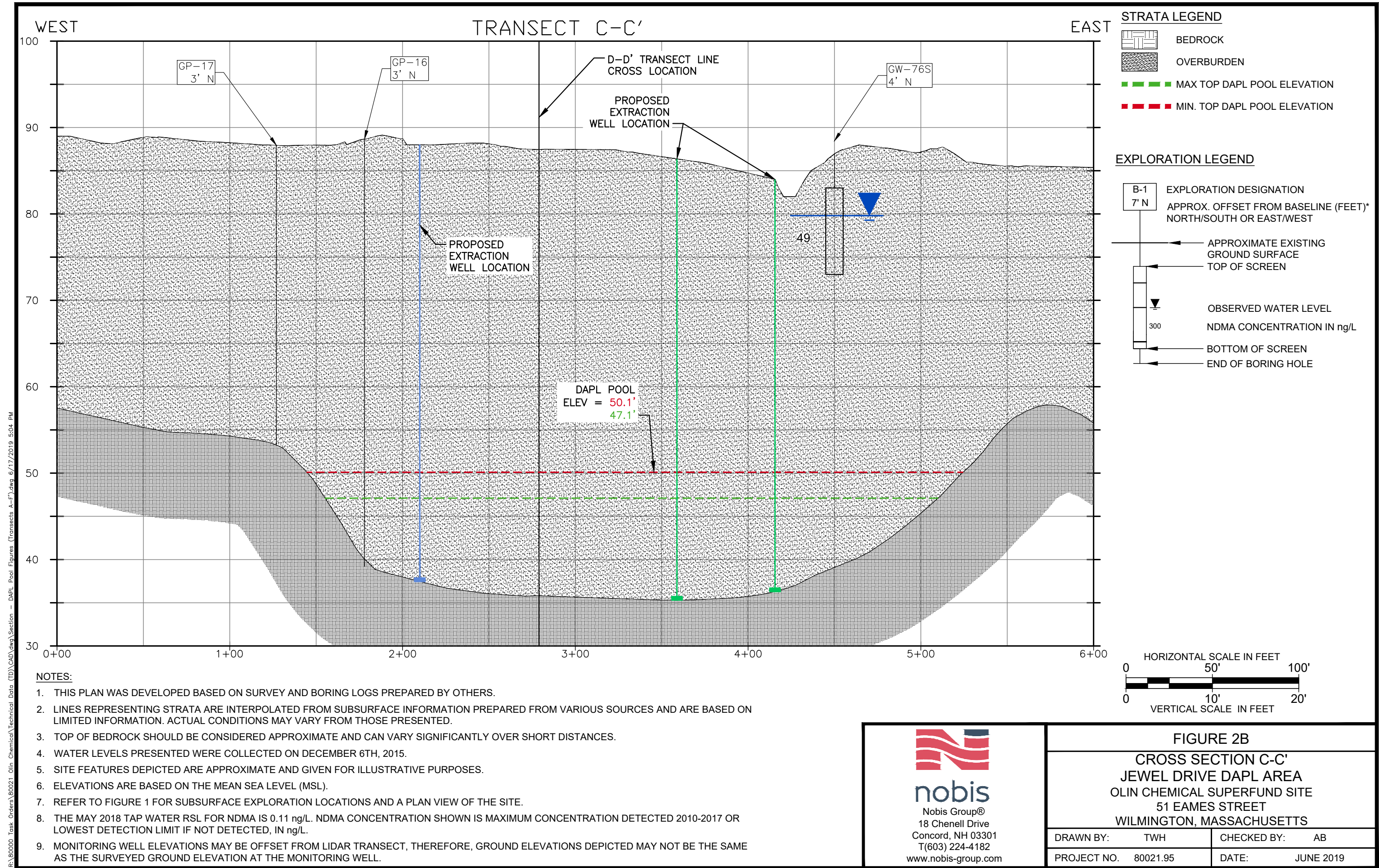


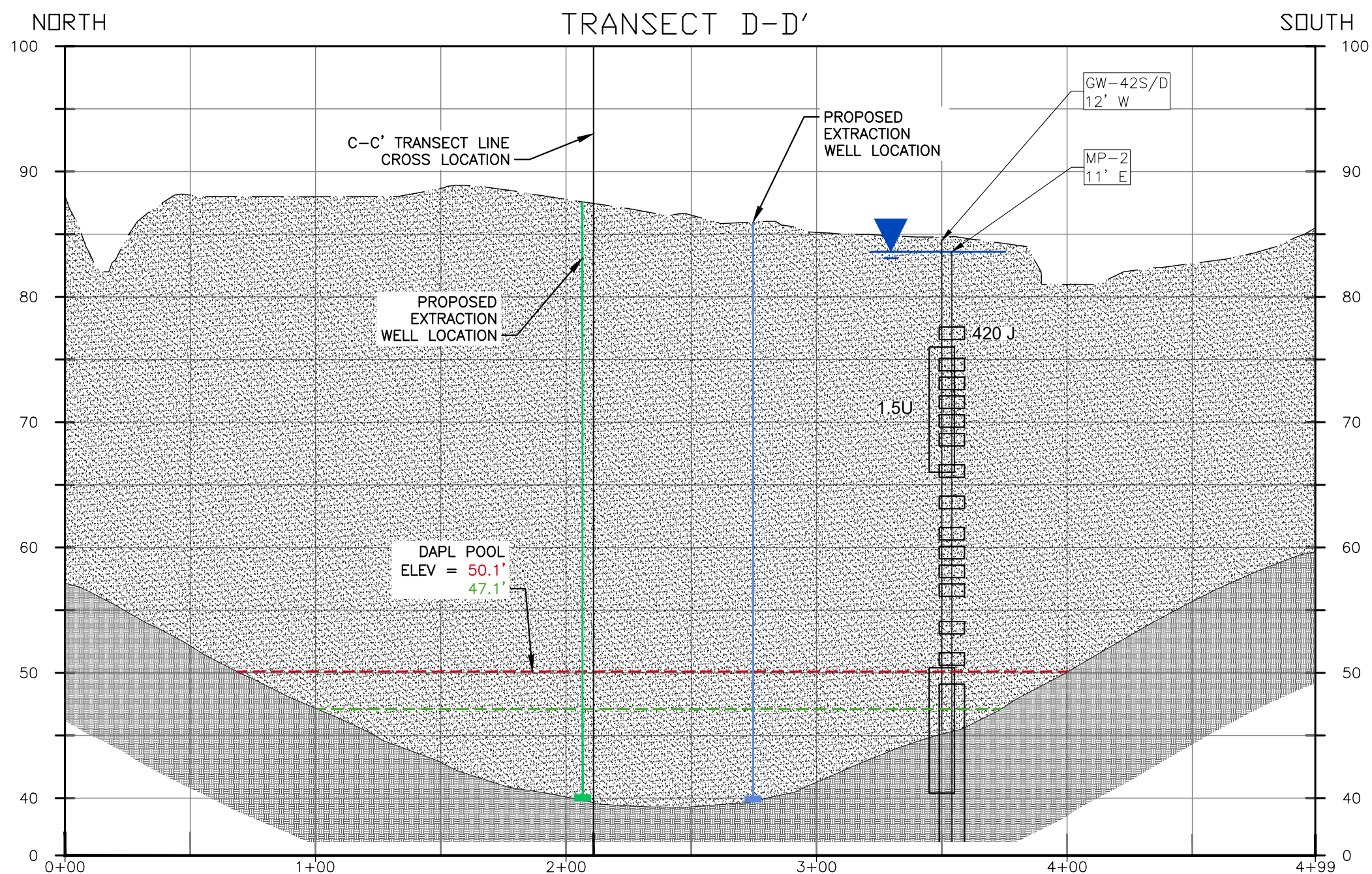
FIGURE 2A

CROSS SECTION TRANSECTS
JEWEL DRIVE
OLIN CHEMICAL SUPERFUND SITE
WILMINGTON, MASSASHUSETTS

PREPARED BY: JH
PROJECT NO. 80021

CHECKED BY: JL
DATE: JUNE 2018

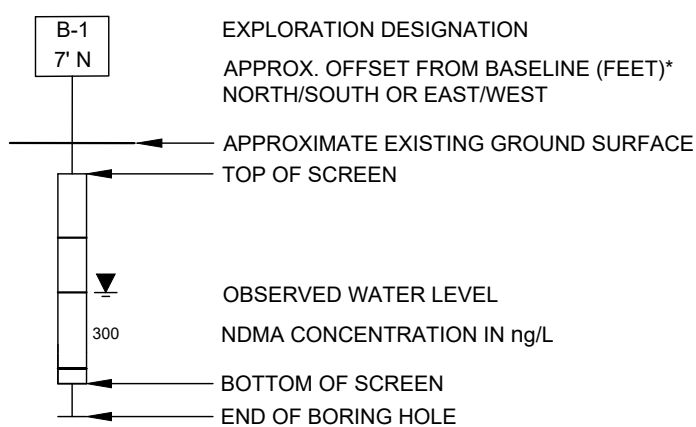




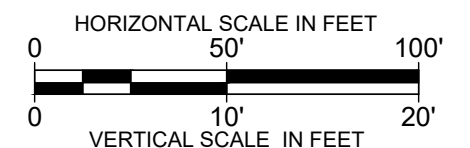
NOTES:

1. THIS PLAN WAS DEVELOPED BASED ON SURVEY AND BORING LOGS PREPARED BY OTHERS.
2. LINES REPRESENTING STRATA ARE INTERPOLATED FROM SUBSURFACE INFORMATION PREPARED FROM VARIOUS SOURCES AND ARE BASED ON LIMITED INFORMATION. ACTUAL CONDITIONS MAY VARY FROM THOSE PRESENTED.
3. TOP OF BEDROCK SHOULD BE CONSIDERED APPROXIMATE AND CAN VARY SIGNIFICANTLY OVER SHORT DISTANCES.
4. WATER LEVELS PRESENTED WERE COLLECTED ON DECEMBER 6TH, 2015.
5. SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
6. ELEVATIONS ARE BASED ON THE MEAN SEA LEVEL (MSL).
7. REFER TO FIGURE 1 FOR SUBSURFACE EXPLORATION LOCATIONS AND A PLAN VIEW OF THE SITE.
8. THE MAY 2018 TAP WATER RSL FOR NDMA IS 0.11 ng/L. NDMA CONCENTRATION SHOWN IS MAXIMUM CONCENTRATION DETECTED 2010-2017 OR LOWEST DETECTION LIMIT IF NOT DETECTED, IN ng/L.
9. MONITORING WELL ELEVATIONS MAY BE OFFSET FROM LIDAR TRANSECT, THEREFORE, GROUND ELEVATIONS DEPICTED MAY NOT BE THE SAME AS THE SURVEYED GROUND ELEVATION AT THE MONITORING WELL.

EXPLORATION LEGEND



STRATA LEGEND



nobis
Nobis Group®
18 Chenell Drive
Concord, NH 03301
T(603) 224-4182
www.nobis-group.com

FIGURE 2C

CROSS SECTION D-D'
JEWEL DRIVE DAPL AREA
OLIN CHEMICAL SUPERFUND SITE
51 EAMES STREET
WILMINGTON, MASSACHUSETTS

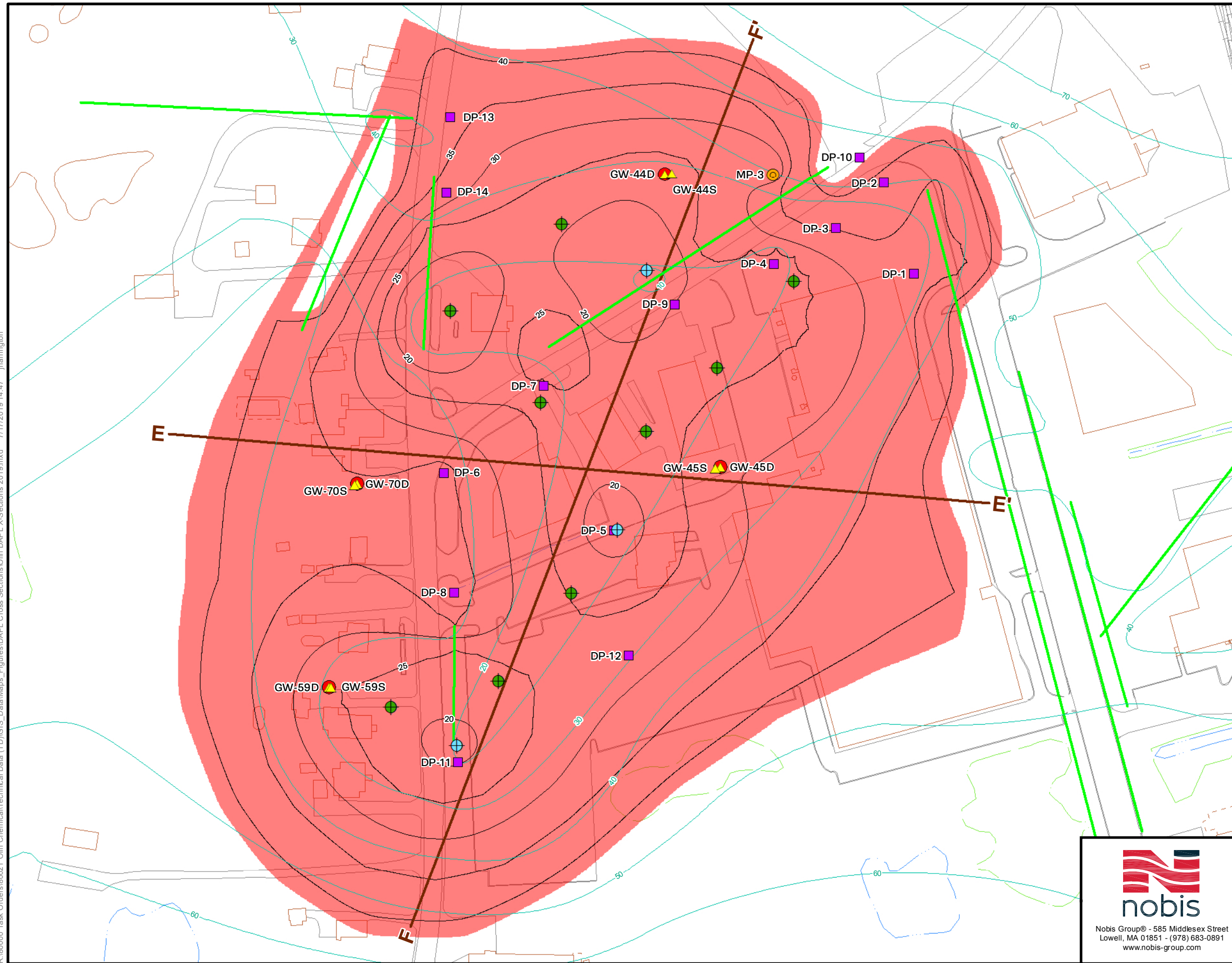
DRAWN BY: TWH

CHECKED BY: AB

PROJECT NO.	80021.95
-------------	----------

DATE:	JUNE 2019
-------	-----------

R:\80000 Task Orders\80021 Olin Chemical\Technical Data (TD)\GIS_Data\Maps_Figures\DAPL Cross Sections\Olin DAPL X-Sections 2019.mxd 7/17/2019 14:47 jharrington



Notes:

1. Bedrock contours from Olin, 2018. Slides to support December 10, 2018 team meeting. Provided December 11.
2. This Site Sketch was developed from elevation data from Mactec, Amec Foster Wheeler, Wood, and observations made by Nobis.
3. Locations of site features depicted hereon are approximate and given for illustrative purposes only.

Legend

- Bedrock Confirmation Location
- Multi-Port Well
- ▲ Conventional Screened Well
- DPT Locations
- ⊕ IAFS Proposed Extraction Well
- Additional DAPL extraction points proposed by Nobis
- Cross Section Transect
- Geophysical Line
- Maximum estimated DAPL extent
- Most recent bedrock contours supplied by Olin
- Nobis Bedrock Contour
- Paved Road
- Rail
- Site Boundary
- Water Features
- Buildings
- Wetlands

0 62.5 125 250
Feet
1 inch = 125 feet

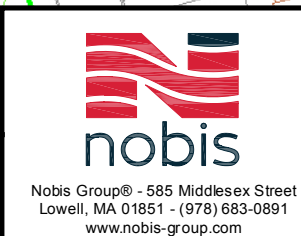


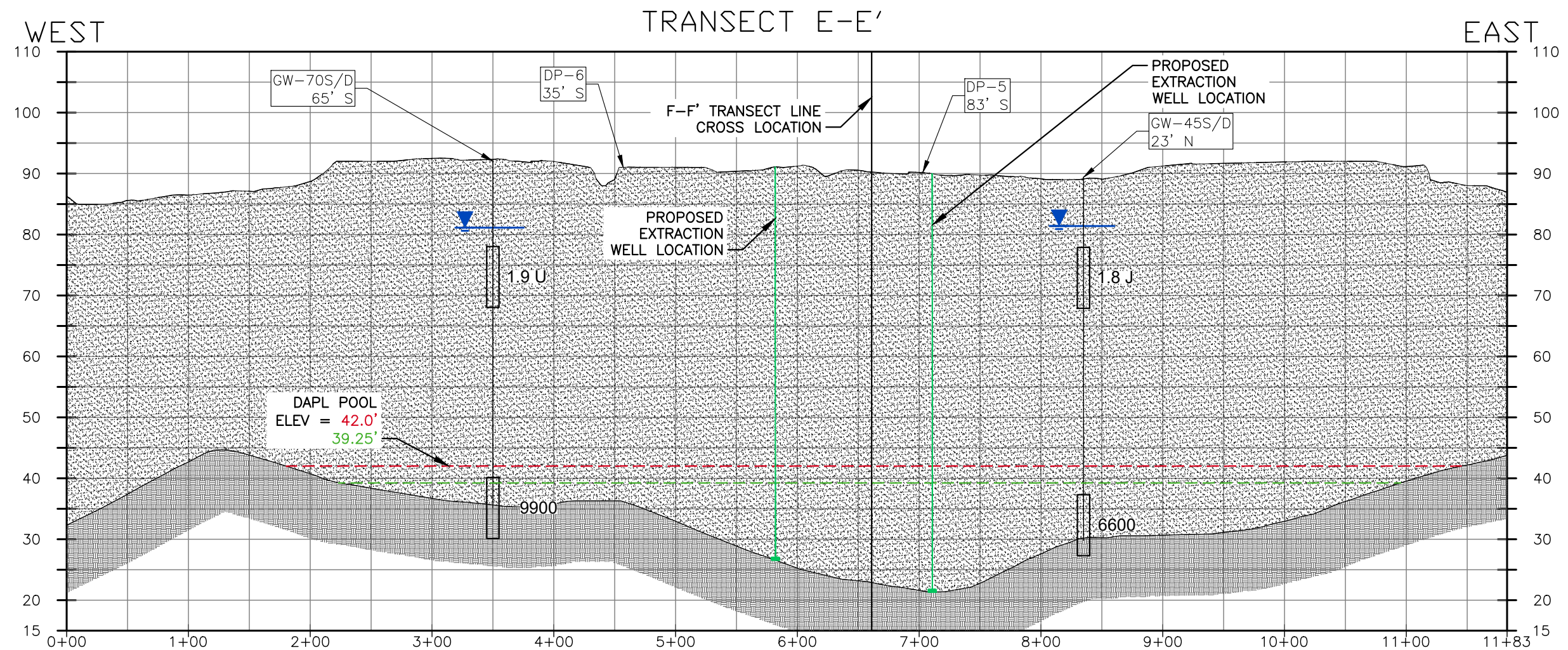
FIGURE 3A

CROSS SECTION TRANSECTS
MAIN STREET
OLIN CHEMICAL SUPERFUND SITE
WILMINGTON, MASSASHUSETTS

PREPARED BY: JH
PROJECT NO. 80021

CHECKED BY: JL
DATE: JUNE 2018

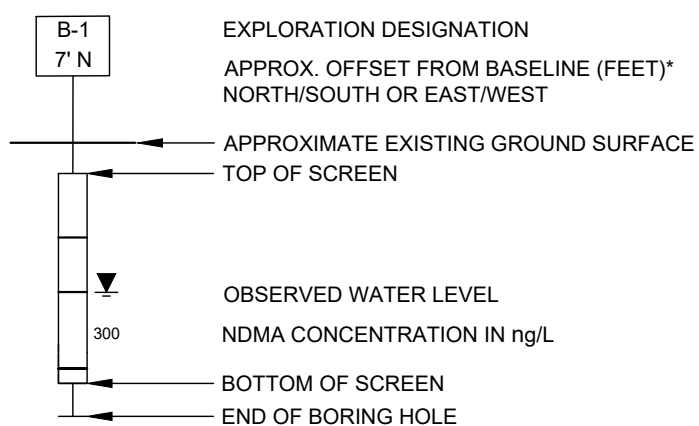
R:\80000 Task Orders\80021 Olin Chemical\Technical Data (TD)\CAD\dwg\Section - DAPL Pool Figures (Transects A-F').dwg 6/17/2019 5:04 PM



NOTES:

1. THIS PLAN WAS DEVELOPED BASED ON SURVEY AND BORING LOGS PREPARED BY OTHERS.
2. LINES REPRESENTING STRATA ARE INTERPOLATED FROM SUBSURFACE INFORMATION PREPARED FROM VARIOUS SOURCES AND ARE BASED ON LIMITED INFORMATION. ACTUAL CONDITIONS MAY VARY FROM THOSE PRESENTED.
3. TOP OF BEDROCK SHOULD BE CONSIDERED APPROXIMATE AND CAN VARY SIGNIFICANTLY OVER SHORT DISTANCES.
4. WATER LEVELS PRESENTED WERE COLLECTED ON DECEMBER 6TH, 2015.
5. SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
6. ELEVATIONS ARE BASED ON THE MEAN SEA LEVEL (MSL).
7. REFER TO FIGURE 1 FOR SUBSURFACE EXPLORATION LOCATIONS AND A PLAN VIEW OF THE SITE.
8. THE MAY 2018 TAP WATER RSL FOR NDMA IS 0.11 ng/L. NDMA CONCENTRATION SHOWN IS MAXIMUM CONCENTRATION DETECTED 2010-2017 OR LOWEST DETECTION LIMIT IF NOT DETECTED, IN ng/L.
9. MONITORING WELL ELEVATIONS MAY BE OFFSET FROM LIDAR TRANSECT, THEREFORE, GROUND ELEVATIONS DEPICTED MAY NOT BE THE SAME AS THE SURVEYED GROUND ELEVATION AT THE MONITORING WELL.

EXPLORATION LEGEND



STRATA LEGEND

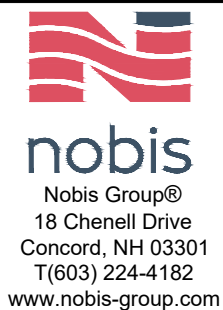
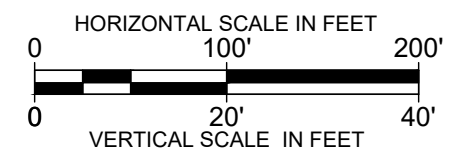
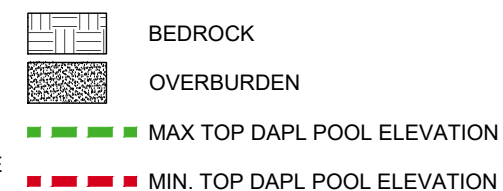
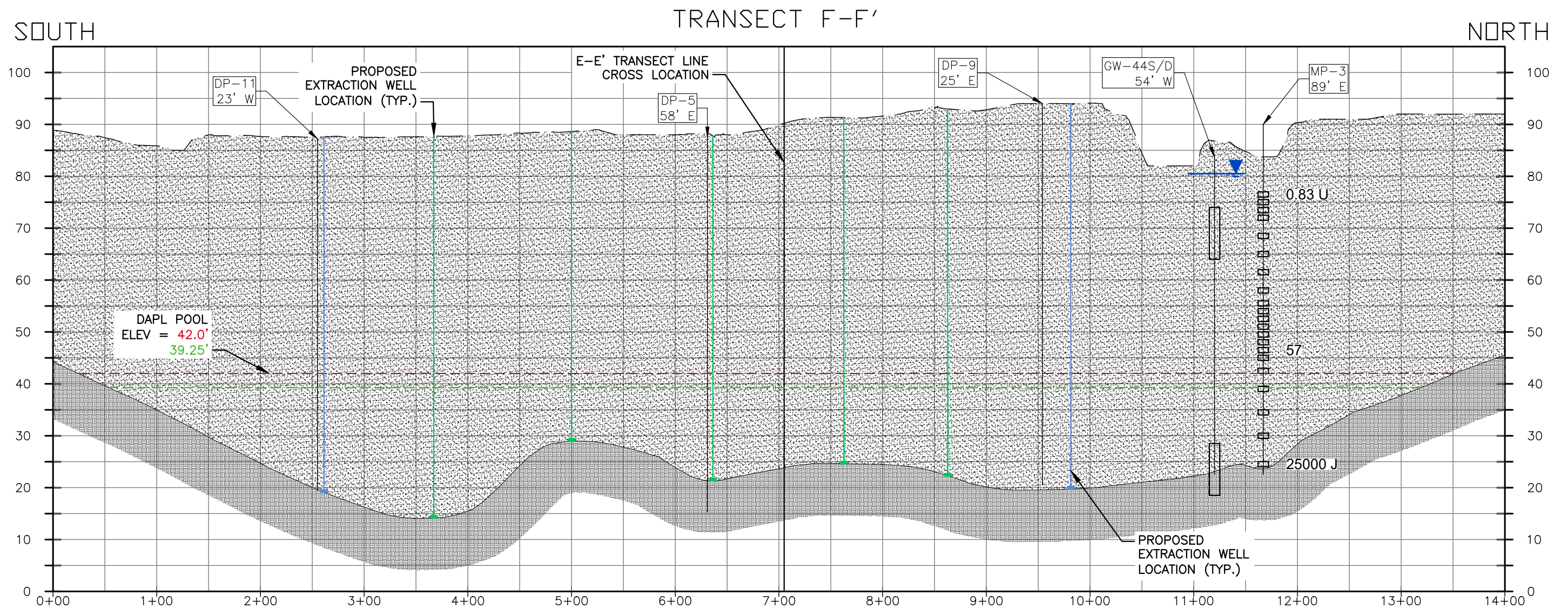


FIGURE 3B	
CROSS SECTION E-E'	
MAIN STREET DAPL AREA	
OLIN CHEMICAL SUPERFUND SITE	
51 EAMES STREET	
WILMINGTON, MASSACHUSETTS	
DRAWN BY:	TWH
CHECKED BY:	AB
PROJECT NO.	80021.95
DATE:	JUNE 2019

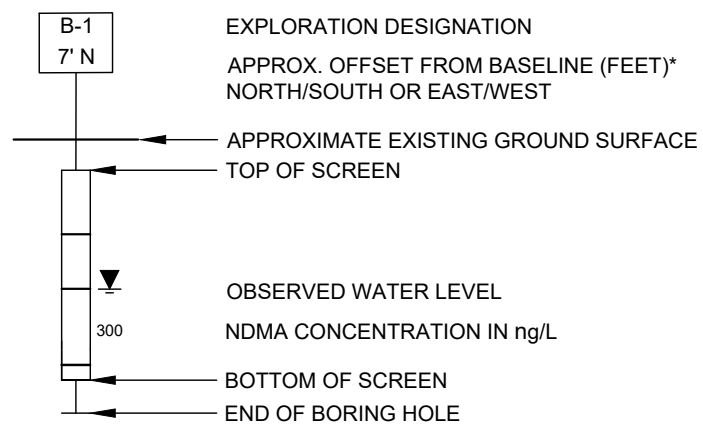
R:\80000 Task Orders\80021 Olin Chemical\Technical Data (TD)\CAD.dwg Section - DAPL Pool Figures (Transects A-F')_dwg 6/17/2019 5:04 PM



NOTES:

1. THIS PLAN WAS DEVELOPED BASED ON SURVEY AND BORING LOGS PREPARED BY OTHERS.
2. LINES REPRESENTING STRATA ARE INTERPOLATED FROM SUBSURFACE INFORMATION PREPARED FROM VARIOUS SOURCES AND ARE BASED ON LIMITED INFORMATION. ACTUAL CONDITIONS MAY VARY FROM THOSE PRESENTED.
3. TOP OF BEDROCK SHOULD BE CONSIDERED APPROXIMATE AND CAN VARY SIGNIFICANTLY OVER SHORT DISTANCES.
4. WATER LEVELS PRESENTED WERE COLLECTED ON DECEMBER 6TH, 2015.
5. SITE FEATURES DEPICTED ARE APPROXIMATE AND GIVEN FOR ILLUSTRATIVE PURPOSES.
6. ELEVATIONS ARE BASED ON THE MEAN SEA LEVEL (MSL).
7. REFER TO FIGURE 1 FOR SUBSURFACE EXPLORATION LOCATIONS AND A PLAN VIEW OF THE SITE.
8. THE MAY 2018 TAP WATER RSL FOR NDMA IS 0.11 ng/L. NDMA CONCENTRATION SHOWN IS MAXIMUM CONCENTRATION DETECTED 2010-2017 OR LOWEST DETECTION LIMIT IF NOT DETECTED, IN ng/L.
9. MONITORING WELL ELEVATIONS MAY BE OFFSET FROM LIDAR TRANSECT, THEREFORE, GROUND ELEVATIONS DEPICTED MAY NOT BE THE SAME AS THE SURVEYED GROUND ELEVATION AT THE MONITORING WELL.

EXPLORATION LEGEND



STRATA LEGEND

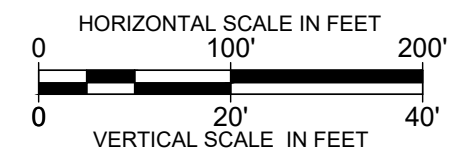
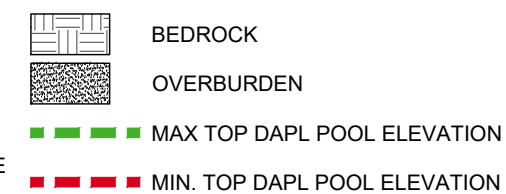


FIGURE 3C
CROSS SECTION F-F'
MAIN STREET DAPL AREA
OLIN CHEMICAL SUPERFUND SITE
51 EAMES STREET
WILMINGTON, MASSACHUSETTS

DRAWN BY:	TWH	CHECKED BY:	AB
PROJECT NO.	80021.95	DATE:	JUNE 2019

Attachment A-1
Containment Area DAPL Pool Cost Comparison
Olin Chemical Superfund Site
Wilmington, Massachusetts
Page 1 of 2

			Nobis Assumptions		Olin Assumptions - IAFS		Olin Assumptions, Nobis Vol.	
Description	Unit Cost	Units	Quantity	Extended Cost	Quantity	Extended Cost	Quantity	Extended Cost
Capital Costs								
Limited Action - Deed Restriction Notification	\$12,400	LS	0	\$0	0	\$0	0	\$0
Remedial Design	\$40,000	LS	1	\$40,000	1	\$40,000	1	\$40,000
DAPL Extraction System Installation								
Mobilization	\$15,000	LS	1	\$15,000	1	\$15,000	1	\$15,000
Temporary Facilities and Controls	\$16,000	LS	1	\$16,000	1	\$16,000	1	\$16,000
Pump Enclosure Vault	\$13,500	LS	1	\$13,500	1	\$13,500	1	\$13,500
Extraction Pump, Controls and Pump Enclosure Piping	\$31,000	LS	1	\$31,000	1	\$31,000	1	\$31,000
Underground DAPL Discharge Piping	\$140	LF	0	\$0	0	\$0	0	\$0
Above Grade DAPL Discharge Piping - Field Fabricated	\$168	LF	350	\$58,800	350	\$58,800	350	\$58,800
Above Grade DAPL Discharge Piping - Prefabricated	\$215	LF	0	\$0	0	\$0	0	\$0
DAPL Storage Tank	\$72,000	LS	1	\$72,000	1	\$72,000	1	\$72,000
Inspection/Cleanout Structures	\$6,125	each	1	\$6,125	1	\$6,125	1	\$6,125
Leak Detection Manhole	\$5,800	LS	1	\$5,800	1	\$5,800	1	\$5,800
Tank Unloading Piping	\$7,500	LS	0	\$0	0	\$0	0	\$0
Above Grade Pipe Support Systems	\$38,750	LS	0.5	\$19,375	0.5	\$19,375	0.5	\$19,375
Railroad Crossing	\$12,000	LS	0	\$0	0	\$0	0	\$0
Chain Link Fence Single (Man) Gates	\$750	each	0	\$0	0	\$0	0	\$0
Electrical and Instrumentation Systems	\$175,000	LS	0.25	\$43,750	0.25	\$43,750	0.25	\$43,750
Multi-Port Monitoring Wells	\$35,000	LS	7	\$245,000	2	\$70,000	2	\$70,000
Induction Logging Wells	\$8,000	LS	7	\$56,000	2	\$16,000	2	\$16,000
System Start-up and Prove-Out	\$15,000	LS	1	\$15,000	1	\$15,000	1	\$15,000
Subtotal				\$597,350		\$382,350		\$382,350
Contingency			20%	\$119,470	20%	\$76,470	20%	\$76,470
Total Capital Costs				\$756,820		\$498,820		\$498,820
Annual Costs								
Electricity	\$900	month	12	\$21,600	12	\$10,800	12	\$10,800
O&M Labor	\$30,000	LS	0	\$0	0	\$0	0	\$0
DAPL Disposal - Deep Well Injection	\$2	gallons	420,480	\$840,960	105,192	\$210,384	105,192	\$210,384
System Performance Monitoring	\$1,440	event	12	\$34,560	12	\$17,280	12	\$17,280
Monitoring and Performance Reports	\$20,000	LS	1	\$20,000	1	\$20,000	1	\$20,000
Total Annual Costs				\$917,120		\$258,464		\$258,464

Attachment A-1
Containment Area DAPL Pool Cost Comparison
Olin Chemical Superfund Site
Wilmington, Massachusetts
Page 2 of 2

Description	Unit Cost	Units	Quantity	Extended Cost	Quantity	Extended Cost	Quantity	Extended Cost	
5-Year Periodic Costs									
5-Year Review Report	\$20,000	LS	1	\$20,000	1	\$20,000	1	\$20,000	
Deed Restriction Verification and Maintenance	\$5,000	LS	0	\$0	0	\$0	0	\$0	
Present Value Analysis									
	Nobis Assumptions			Olin Assumptions - IAFS			Olin Assumptions - Nobis Vol.		
Cost Type	Total Cost	Discount Factor	Present Value	Total Cost	Discount Factor	Present Value	Total Cost	Discount Factor	Present Value
Capital Costs - Year 0	\$756,820	1.0000	\$ 756,820	\$498,820	1.0000	\$ 498,820	\$498,820	1.0000	\$ 498,820
Annual Costs - Year 1	\$917,120	0.9728	\$ 892,174	\$258,464	0.9728	\$ 251,434	\$258,464	0.9728	\$ 251,434
Annual Costs - Year 2	\$458,560	0.9463	\$ 433,935	\$258,464	0.9463	\$ 244,584	\$258,464	0.9463	\$ 244,584
Annual Costs - Year 3	\$0	0.9205	\$ -		0.9205	\$ -	\$258,464	0.9205	\$ 237,916
Annual Costs - Year 4	\$0	0.8954	\$ -		0.8954	\$ -	\$258,464	0.8954	\$ 231,429
5-Year Periodic Costs - Year 5	\$20,000	0.8710	\$ 17,420	\$20,000	0.8710	\$ 17,420	\$20,000	0.8710	\$ 17,420
Annual Costs - Year 5	\$0	0.8710	\$ -		0.8710	\$ -	\$258,464	0.8710	\$ 225,122
Annual Costs - Year 6	\$0	0.8473	\$ -		0.8473	\$ -	\$258,464	0.8473	\$ 218,997
Annual Costs - Year 7	\$0	0.8242	\$ -		0.8242	\$ -	\$0	0.8242	\$ -
Annual Costs - Year 8	\$0	0.8018	\$ -		0.8018	\$ -	\$0	0.8018	\$ -
Annual Costs - Year 9	\$0	0.7799	\$ -		0.7799	\$ -	\$0	0.7799	\$ -
Annual Costs - Year 10	\$0	0.7587	\$ -		0.7587	\$ -	\$0	0.7587	\$ -
5-Year Periodic Costs - Year 10	\$0	0.7587	\$ -		0.7587	\$ -	\$10,000	0.7587	\$ 7,587
Total:	\$2,152,500		\$2,100,350	\$1,035,748		\$1,012,258	\$2,079,604		\$1,933,309

Notes:

1. See IAFS (Wood, 2019) for costing assumption details. Annual electricity, monitoring costs (red) assumed to double for Nobis additional pumping well scenario
2. Annual pumping rate based on pumping rate provided (GPM) at an operating time of 80%. Nobis calculated annual pumping rate used for Nobis calculations only.
3. Years of operation rounded up to nearest half year for annual costs.

pumping rate:
operating time:
pumping rate:

Nobis		Olin	
1	gpm	0.25	gpm
80%		80%	
420,480	gal/year	105,120	gal/year

Attachment A-2
Jewel Drive/OPWD DAPL Pool Cost Comparison
Olin Chemical Superfund Site
Wilmington, Massachusetts
Page 1 of 2

			Nobis Assumptions		Olin Assumptions - IAFS		Olin Assumptions, Nobis Vol.	
Description	Unit Cost	Units	Quantity	Extended Cost	Quantity	Extended Cost	Quantity	Extended Cost
Capital Costs								
Limited Action - Deed Restriction Notification	\$12,400	LS	0	\$0	0	\$0	0	\$0
Replacement DAPL Extraction Well	\$45,000	LS	3	\$135,000	1	\$45,000	1	\$45,000
Geophysical Investigation	\$15,000	LS	1	\$15,000	1	\$15,000	1	\$15,000
Additional DAPL Extraction Well(s)								
Mobilization	\$16,000	LS	1	\$16,000	1	\$16,000	1	\$16,000
Temporary Facilities and Controls	\$13,500	LS	1	\$13,500	1	\$13,500	1	\$13,500
Pump Enclosure Vault	\$31,000	LS	1	\$31,000	1	\$31,000	1	\$31,000
Extraction Pump, Controls and Pump Enclosure Piping	\$31,000	LS	1	\$31,000	1	\$31,000	1	\$31,000
Underground DAPL Discharge Piping	\$168	LF	200	\$33,600	200	\$33,600	200	\$33,600
Electrical and Instrumentation Systems	\$175,000	LS	0.5	\$87,500	0.25	\$43,750	0.25	\$43,750
Multi-Port Monitoring Wells	\$35,000	LS	6	\$210,000	1	\$35,000	1	\$35,000
Induction Logging Wells	\$8,000	LS	6	\$48,000	1	\$8,000	1	\$8,000
System Start-up and Prove-Out	\$15,000	LS	1	\$15,000	1	\$15,000	1	\$15,000
Subtotal				\$485,600		\$226,850		\$226,850
Contingency			20%	\$97,120	20%	\$45,370	20%	\$45,370
Total Capital Costs				\$732,720		\$332,220		\$332,220
Annual Costs								
Electricity	\$900	month	12	\$21,600	12	\$10,800	12	\$10,800
O&M Labor	\$30,000	LS	0	\$0	0	\$0	0	\$0
DAPL Disposal - Deep Well Injection	\$2	gallons	420,480	\$840,960	105,192	\$210,384	105,192	\$210,384
System Performance Monitoring	\$1,440	event	12	\$34,560	12	\$17,280	12	\$17,280
Monitoring and Performance Reports	\$20,000	LS	1	\$20,000	1	\$20,000	1	\$20,000
Total Annual Costs				\$917,120		\$258,464		\$258,464

Attachment A-2
Jewel Drive/OPWD DAPL Pool Cost Comparison
Olin Chemical Superfund Site
Wilmington, Massachusetts
Page 2 of 2

Description	Unit Cost	Units	Quantity	Extended Cost	Quantity	Extended Cost	Quantity	Extended Cost	
5-Year Periodic Costs									
5-Year Review Report	\$20,000	LS	1	\$20,000	1	\$20,000	1	\$20,000	
Deed Restriction Verification and Maintenance	\$5,000	LS	0	\$0	0	\$0	0	\$0	
Present Value Analysis									
	Nobis Assumptions			Olin Assumptions - IAFS			Olin Assumptions - Nobis Vol.		
Cost Type	Total Cost	Discount Factor	Present Value	Total Cost	Discount Factor	Present Value	Total Cost	Discount Factor	Present Value
Capital Costs - Year 0	\$732,720	1.0000	\$ 732,720	\$332,220	1.0000	\$ 332,220	\$332,220	1.0000	\$ 332,220
Annual Costs - Year 1	\$917,120	0.9728	\$ 892,174	\$258,464	0.9728	\$ 251,434	\$258,464	0.9728	\$ 251,434
Annual Costs - Year 2	\$917,120	0.9463	\$ 867,871	\$258,464	0.9463	\$ 244,584	\$258,464	0.9463	\$ 244,584
Annual Costs - Year 3	\$917,120	0.9205	\$ 844,209	\$258,464	0.9205	\$ 237,916	\$258,464	0.9205	\$ 237,916
Annual Costs - Year 4	\$458,560	0.8954	\$ 410,595	\$258,464	0.8954	\$ 231,429	\$258,464	0.8954	\$ 231,429
5-Year Periodic Costs - Year 5	\$20,000	0.8710	\$ 17,420	\$20,000	0.8710	\$ 17,420	\$20,000	0.8710	\$ 17,420
Annual Costs - Year 5	\$0	0.8710	\$ -	\$258,464	0.8710	\$ 225,122	\$258,464	0.8710	\$ 225,122
Annual Costs - Year 6	\$0	0.8473	\$ -	\$258,464	0.8473	\$ 218,997	\$258,464	0.8473	\$ 218,997
Annual Costs - Year 7	\$0	0.8242	\$ -	\$258,464	0.8242	\$ 213,026	\$258,464	0.8242	\$ 213,026
Annual Costs - Year 8	\$0	0.8018	\$ -	\$258,464	0.8018	\$ 207,236	\$258,464	0.8018	\$ 207,236
Annual Costs - Year 9	\$0	0.7799	\$ -	\$258,464	0.7799	\$ 201,576	\$258,464	0.7799	\$ 201,576
Annual Costs - Year 10	\$0	0.7587	\$ -	\$129,232	0.7587	\$ 98,048	\$258,464	0.7587	\$ 196,097
5-Year Periodic Costs - Year 10	\$0	0.7587	\$ -	\$10,000	0.7587	\$ 7,587	\$10,000	0.7587	\$ 7,587
Annual Costs - Year 11	\$0	0.7380	\$ -	\$0	0.7380	\$ -	\$258,464	0.7380	\$ 190,746
Annual Costs - Year 12	\$0	0.7179	\$ -	\$0	0.7179	\$ -	\$258,464	0.7179	\$ 185,551
Annual Costs - Year 13	\$0	0.6984	\$ -	\$0	0.6984	\$ -	\$258,464	0.6984	\$ 180,511
Annual Costs - Year 14	\$0	0.6794	\$ -	\$0	0.6794	\$ -	\$129,232	0.6794	\$ 87,800
Annual Costs - Year 15	\$0	0.6609	\$ -	\$0	0.6609	\$ -	\$0	0.6609	\$ -
5-Year Periodic Costs - Year 15	\$0	0.6609	\$ -	\$0	0.6609	\$ -	\$10,000	0.6609	\$ 6,609
Total:	\$3,962,640		\$3,764,989	\$2,817,628		\$2,486,596	\$2,946,860		\$2,584,644

Notes:

1. See IAFS (Wood, 2019) for costing assumption details. Annual electricity, monitoring costs (red) assumed to double for Nobis additional pumping well scenario
2. Annual pumping rate based on pumping rate provided (GPM) at an operating time of 80%. Nobis calculated annual pumping rate used for Nobis calculations only.
3. Years of operation rounded up to nearest half year for annual costs.

pumping rate:
operating time:
pumping rate:

Nobis		Olin	
1	gpm	0.25	gpm
80%		80%	
420,480	gal/year	105,120	gal/year

Attachment A-3
Main Street DAPL Pool Cost Comparison
Olin Chemical Superfund Site
Wilmington, Massachusetts
Page 1 of 2

			Nobis Assumptions		Olin Assumptions - IAFS		Olin Assumptions, Nobis Vol.	
Description	Unit Cost	Units	Quantity	Extended Cost	Quantity	Extended Cost	Quantity	Extended Cost
Capital Costs								
Limited Action - Deed Restriction Notification	\$12,400	LS	0	\$0	0	\$0	0	\$0
Geophysical Investigation	\$30,000	LS	1	\$30,000	1	\$30,000	1	\$30,000
Remedial Design	\$60,000	LS	1	\$60,000	1	\$60,000	1	\$60,000
Additional DAPL Extraction Well(s)								
Mobilization	\$20,000	LS	1	\$20,000	1	\$20,000	1	\$20,000
Temporary Facilities and Controls	\$16,000	LS	1	\$16,000	1	\$16,000	1	\$16,000
Pump Enclosure Vault	\$13,500	LS	3	\$40,500	3	\$40,500	3	\$40,500
Extraction Pump, Controls and Pump Enclosure Piping	\$31,000	LS	3	\$93,000	3	\$93,000	3	\$93,000
Underground DAPL Discharge Piping	\$140	LF	4000	\$560,000	2000	\$280,000	2000	\$280,000
Above Grade DAPL Discharge Piping	\$200	LF	550	\$110,000	550	\$110,000	550	\$110,000
DAPL Storage Tank	\$72,000	LS	2	\$144,000	2	\$144,000	2	\$144,000
Inspection/Cleanout Structures	\$6,125	each	8	\$49,000	8	\$49,000	8	\$49,000
Leak Detection Manhole	\$5,800	LS	1	\$5,800	1	\$5,800	1	\$5,800
Tank Unloading Piping	\$7,500	LS	2	\$15,000	2	\$15,000	2	\$15,000
Above Grade Pipe Support Systems	\$38,750	LS	1	\$38,750	1	\$38,750	1	\$38,750
Railroad Crossing	\$12,000	LS	1	\$12,000	1	\$12,000	1	\$12,000
Chain Link Fence Single (Man) Gates	\$750	each	0	\$0	0	\$0	0	\$0
Electrical and Instrumentation Systems	\$262,500	LS	1	\$262,500	1	\$262,500	1	\$262,500
Multi-Port Monitoring Wells	\$35,000	LS	24	\$840,000	3	\$105,000	3	\$105,000
Induction Logging Wells	\$8,000	LS	24	\$192,000	3	\$24,000	3	\$24,000
System Start-up and Prove-Out	\$15,000	LS	1	\$15,000	1	\$15,000	1	\$15,000
Subtotal				\$2,413,550		\$1,230,550		\$1,230,550
Contingency			20%	\$482,710	20%	\$246,110	20%	\$246,110
Total Capital Costs				\$2,986,260		\$1,566,660		\$1,566,660
Annual Costs								
Electricity	\$900	month	12	\$21,600	12	\$10,800	12	\$10,800
O&M Labor	\$30,000	LS	0	\$0	0	\$0	0	\$0
DAPL Disposal - Deep Well Injection	\$2	gallons	2,522,880	\$5,045,760	2,524,608	\$5,049,216	2,524,608	\$5,049,216
System Performance Monitoring	\$4,320	event	12	\$103,680	12	\$51,840	12	\$51,840
Monitoring and Performance Reports	\$20,000	LS	1	\$20,000	1	\$20,000	1	\$20,000
Total Annual Costs				\$5,191,040		\$5,131,856		\$5,131,856

Attachment A-3
Main Street DAPL Pool Cost Comparison
Olin Chemical Superfund Site
Wilmington, Massachusetts
Page 2 of 2

Description	Unit Cost	Units	Quantity	Extended Cost	Quantity	Extended Cost	Quantity	Extended Cost
5-Year Periodic Costs								
5-Year Review Report	\$20,000	LS	1	\$20,000	1	\$20,000	1	\$20,000
Deed Restriction Verification and Maintenance	\$5,000	LS	0	\$0	0	\$0	0	\$0
Present Value Analysis								
	Nobis Assumptions			Olin Assumptions - IAFS			Olin Assumptions - Nobis Vol.	
Cost Type	Total Cost	Discount Factor	Present Value	Total Cost	Discount Factor	Present Value	Total Cost	Present Value
Capital Costs - Year 0	\$2,986,260	1.0000	\$ 2,986,260	\$1,566,660	1.0000	\$ 1,566,660	\$1,566,660	\$ 1,566,660
Annual Costs - Year 1	\$5,191,040	0.9728	\$ 5,049,844	\$5,131,856	0.9728	\$ 4,992,270	\$5,131,856	\$ 4,992,270
Annual Costs - Year 2	\$5,191,040	0.9463	\$ 4,912,281	\$5,131,856	0.9463	\$ 4,856,275	\$5,131,856	\$ 4,856,275
Annual Costs - Year 3	\$5,191,040	0.9205	\$ 4,778,352	\$5,131,856	0.9205	\$ 4,723,873	\$5,131,856	\$ 4,723,873
Annual Costs - Year 4	\$5,191,040	0.8954	\$ 4,648,057	\$5,131,856	0.8954	\$ 4,595,064	\$5,131,856	\$ 4,595,064
5-Year Periodic Costs - Year 5	\$20,000	0.8710	\$ 17,420	\$20,000	0.8710	\$ 17,420	\$20,000	\$ 17,420
Annual Costs - Year 5	\$5,191,040	0.8710	\$ 4,521,396	\$5,131,856	0.8710	\$ 4,469,847	\$5,131,856	\$ 4,469,847
Annual Costs - Year 6	\$5,191,040	0.8473	\$ 4,398,368	\$1,026,371	0.8473	\$ 869,644	\$5,131,856	\$ 4,348,222
Annual Costs - Year 7	\$5,191,040	0.8242	\$ 4,278,455	\$0	0.8242	\$ -	\$5,131,856	\$ 4,229,676
Annual Costs - Year 8	\$0	0.8018	\$ -	\$0	0.8018	\$ -	\$0	\$ -
Annual Costs - Year 9	\$0	0.7799	\$ -	\$0	0.7799	\$ -	\$0	\$ -
Annual Costs - Year 10	\$0	0.7587	\$ -	\$0	0.7587	\$ -	\$0	\$ -
5-Year Periodic Costs - Year 10	\$10,000	0.7587	\$ 7,587	\$0	0.7587	\$ -	\$0	\$ -
Annual Costs - Year 11	\$0	0.7380	\$ -	\$0	0.7380	\$ -	\$0	\$ -
Annual Costs - Year 12	\$0	0.7179	\$ -	\$0	0.7179	\$ -	\$0	\$ -
Annual Costs - Year 13	\$0	0.6984	\$ -	\$0	0.6984	\$ -	\$0	\$ -
Annual Costs - Year 14	\$0	0.6794	\$ -	\$0	0.6794	\$ -	\$0	\$ -
Annual Costs - Year 15	\$0	0.6609	\$ -	\$0	0.6609	\$ -	\$0	\$ -
5-Year Periodic Costs - Year 15	\$0	0.6609	\$ -	\$0	0.6609	\$ -	\$0	\$ -
Total:	\$39,353,540		\$35,598,021	\$28,272,311		\$26,091,053	\$37,509,652	\$33,799,306

Notes:

1. See IAFS (Wood, 2019) for costing assumption details. Annual electricity, monitoring costs (red) assumed to double for Nobis additional pumping well scenario
2. Annual pumping rate based on pumping rate provided (GPM) at an operating time of 80%. Nobis calculated annual pumping rate used for Nobis calculations only.
3. Years of operation rounded up to nearest half year for annual costs.

pumping rate:
operating time:
pumping rate:

Nobis	Olin
6 gpm	6 gpm
80%	80%
2,522,880 gal/year	2,522,880 gal/year